REPORT ON THE REQUIREMENTS OF PREFABRICATED DEMOUNTABLE BUILDINGS FOR ARCTIC USE

The Eskimo igloo has for hundreds of years served the purpose of housing for the natives of the arctic. Through long experience it has been well adapted to the environment.

The circular shape prevents the igloo from being engulfed in snowdrifts. The snow wall is cut to a specific thickness to provide a comfortable shelter. It has been proved that when the wall is about 6 inches thick the cold from outside the igloo and the heat from the inside meet in the center of the wall - the so-called neutral center. The ventilator hole is also of a specific diameter and the hole is placed at a 45 degree angle from the center of the igloo, opening toward the lee side. This arrangement keeps the ventilator from dripping.

The entrance to the igloo is lower than the floor of the living room and the floor of the tunnel slopes gradually from the entrance upwards. In the igloo itself is a platform about 2 feet above floor level. This platform is the living space on which the Eskimos do their work, eat their meals, and sleep. The igloo also has an anteroom that serves as a storeroom and a place for removing snow from the clothing before entering the main room.

The fundamental principle of Arctic housing in the following report is based on the Eskimo technique of igloo design.

Climatic Considerations

Prefabricated buildings for Arctic use should be standardized, but because of the variations in climatic conditions that exist in the Arctic from the Aleutians to Greenland any standardisation must allow for modifications to meet the requirements of the particular region or particular site within the region. There are orographic winds in moutainous areas that will cause one site to be relatively free of snow-drift and another to be constantly subjected to heavy accumulation of snow. There are in certain Arctic areas, valleys and fjords, where foehn winds strike with sudden violence reaching velocities of 150 miles an hour. In general, the modifications to a standardized prefabricated house will be required to meet:

a. Violent winds

b. Heavy snow accumulations

c. Heavy rains in summer

The Arctic winter climate is fairly uniform because of the comparative lack of precipitation due to the vast areas of frozen seas and the consistently low temperatures. Very cold air holds very little moisture. In spite of small precipitation in the Arctic in winter, constant high winds cause drifting snow which fill valleys or build up on lee slopes to depths of 30 feet. The determination of the location of any camp site is of the greatest importance. Careful analysis of local winds, prevailing winds, areas of deep drifts must be made before modifications can be made to meet eventualities.

It is advisable to place the buildings well up the side of hillslopes, or even atop low ridges, to avoid being engulfed (buried) in wind-driven drifts of snow.

At the Mould Bay Weather Station on Prince Patrick Island, N. W. T., the camp is built on top of a small hill. Of all the U. S. Weather Stations this one is always clear of high snow-drifts around the buildings. The main building is put up on oil barrels (piers) and this has proven very successful. But the floor must be provided with double floors with extra insulation to prevent heatloss.

In terrain where shale and gravel and slate are present, the buildings are erected on the sites where such material is most evident. On the ice-cap it is necessary to dig to hard snow or ice before erecting any building. In that case provision must be made to add extra sections to the top of the ventilator to keep it above the accumulated snow during the winter.

If a camp is to be built in a flat terrain where there are no hills, but high mountains in the back of this area, the surrounding land must be carefully studied. I have seen huts in Greenland that have been erected in the fall on dry land, standing in water in the spring when the melting snow from the mountains rushes towards the still frozen bay and this bay-ice will act as a barrier and prevent the water from flowing into the ocean or bay and large lakes will form on the flat land.

Shape and size of buildings for various purposes

Due to variations in wind direction, with resulting variations in heavy snowdrift, the buildings should be designed to allow minimum

resistance to the free flow of air to prevent the buildings from being buried by snow banks. The streamline design is advocated as far as possible or a modification such as the Higgin's hut. To obtain the maximum heat conservation in the Arctic, buildings are generally small and with low ceilings about 8' high.

Buildings are often connected by snow-tunnels or corridors and erected in such a relation to each other as to prevent heavy accumulation of snow between. Generally, buildings should be placed at an angle with a corner facing the prevailing winds and the vestibule on the windward side as shown in the accompanying diagram.

Insulation panels and curtain walls and/or self-contained structural units

The main problem with insulation is to protect it from moisture. Condensation will form to freeze to ice and destroy its effectiveness and in the summer the ice will melt and the water will ruin the insulation materials.

Insulation of two separate dead-air spaces has proven very satisfactory. Tests have found the best width of one dead air-space to be 2 inches. Dead air-space panels must be sealed so that no air will penetrate into dead air-spaces.

Fiber glass and rockwool are also excellent for insulation when

provided with extra dead air-space.

When antenna wires, electric wires or pipes extend through walls or roof, they must be sealed and insulated from dead air-space. Where it is necessary to make holes for wiring, every hole and crack, no matter how small, must be plugged, as snow can blow through any aperture in an Arctic gale.

The Danish Weather Station at Thule, Greenland is insulated with panels of excelsior coated with cement. It is used on walls, floor and roof. The house is very dry and comfortable to live in.

Machine shops and engine rooms must be lined with asbestos sheeting on walls and on the ceiling for fire protection.

Double or triple windows are a necessary feature of all Arctic buildings, and should be placed high in the walls. To prevent warping, windows should be built so that they cannot be opened. Window shades or blinds are needed for protection against glare from sun shining on snow and also for midnight sun.

The main door should be modeled on the refrigerator door design for maximum insulation and resistance to wind pressure, and should open inward for free exit after storms and periods of heavy drift. The outside door-sill should be 8 inches higher than the floor to prevent snow and ice from forming under door. A small door, about 3 1/2 feet high, should be set into the outside door of the living quarters and any other heavy outside doors to facilitate the passage of one man with the least loss of heat and entrance of snow. There should be two regular exits for each building plus an emergency exit from the roof. All outside doors should be in-

sulated. Mosquito screened doors are needed for the summer months in places from the sub-arctic to 75 N. Lat.

Vestibules should have 2 windows 18" x 18", leading into a small hall way with a Dutch-type door opening into the room. The vestibule and hall-way should be large enough to accommodate shelves for outdoor equipment such as axes, guns, binoculars, cameras, etc., and equipped with hooks for parkas and other outer clothing. A footscraper should be provided to prevent unnecessary tracking of snow, ice and dirt into the living quarters. All shelves, beds, cupboards, etc., must be placed at least 1" distant from the outer walls to allow free circulation of air to avoid condensation and freezing.

The floor level of the vestibule should be lower than that of the living quarters to prevent any possible admission of cold air and drifting snow. All floors in the building should be insulated or have a double floor separated with dead air-space or can be used for a duct for hot air to circulate. The floor in the vestibule does not need to be insulated. In permafrost areas, there should be a space of a foot or more between the floors and the ground.

Partitions between sleeping quarters should leave a clearance of 1' at the bottom and 2' at the top for free circulation. If individual rooms are not used bunks should be separated by curtains. There should be sufficient vents for individual adjustment in sleeping quarters and all ventilators should extend vertically through and beyond the roof, to prevent clogging with resulting condensation of snow during periods of high winds. Exhaust pipes from engines should also extend above the roof. To prevent dripping and freeze-up, ventilators and smoke jacks should be of the special insulated type. When a building is left unoccupied the ventilator must be left open to prevent hoarfrost from forming. The importance of sufficient ventilation and free circulation air cannot be overemphasized.

Kiln-dried wood is best for prevention of warping of splitting which is so prevalent in low-temperature areas when wood is used in any part of construction. Impregnated masonite (masonite coated with resin) has proven extremely successful, withstanding years of exposure with no ill effects. Tar-paper is good insulation but is difficult to handle in cold weather. Skin-stressed plywood is excellent.

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Report on equipment and structures in Arctic

Natural sources of insulation are snow, moss, seaweed, and turf peat. Such insulation materials should be laid so as to leave a free air-space 1"-2" wide between the building wall and the material.

An outer shed adjoining the toilet should be equipped with a sled upon which a large oil drum can be placed to receive the refuse leading

down from the tiolet seat. The sled and drum can be pulled away when latter is full. A sliding panel closes off the opening during change. The tiolet room should be provided with one or more ventilators depending on size.

A storage shed for ice-blocks as emergency water supply should adjoin the kitchen area with an insulated door of the refrigerator door type leading into the kitchen where a box is placed next to the stove to hold the ice for melting before flowing into pipes for additional hot water. When water is pumped from a frozen lake, the well shaft should be filled with gasoline when not in use and the gasoline burned before the next use. This prevents freezing and unnecessary work digging a new ice hole.

For disposal of dishwater, laundry water, etc., drain pipes leading from disposal collectors should be one and one-half inches in diameter. To prevent freezing or clogging up, the pipes should be insulated in wooden boxes (utilidors) packed with insulating materials.

The kitchen, washroom, and toilets should be located on the side of the building that faces downgrade making it easier to get under the house to repair possible damages to pipes. The kitchen should be in a separate room to prevent steam from the cooking of food from condensing on walls, ceilings, and floors of adjoining rooms.

A Finnish bath is recommended as a measure for conservation of water as well as a morale builder and health measure. It is aid that the Russian and Finnish armies carry the makings of Finnish baths to the war front and by them, the army is kept clean and free from disease. The soldiers roll in the snow after the bath, thus helping keep up their resistance to the bitter cold.

Doctors have made tests of the heart actions of men before and after taking these baths in mid-winter, when an icy plunge into the pool or roll in the snow has been the climax, and found no difference in the heart heat.

Packaging

Building materials should be assembled in packages which should be steel-strapped. All crates should be viewed with mindfulness of their future usefulness as a source of building materials. Where they might be used as a temporary shelter, they should be designed in large sections plainly marked for quick easy assembling and handling. They should have heavy rope handles with holes large enough so the rope can be pushed into the crate for space economy in shipping. Extra ropes should be placed in the crates to be used in securing temporary partitions against high winds. All hardware and miscellaneous small parts must be strongly boxed.

Romex wires and similar insulated wires have been found most satisfactory for Arctic use.

Air Transportability

No crate should weigh more than 400 pounds and should have sliding rope handles as mentioned above. Crates should be removed from the vicinity of the plane as soon as possible to avoid accidents and damage

to both plane and unloaded equipment from the strong slipstream created by the propellors when the plane takes off.

The best months for air transportation in the Arctic are March and April but as the minimum temperatures during these months may be from -20 to -50 F., every care must be taken to facilitate speedy unloading and erection temporary shelter. The change from temperate to arctic weather has a demoralizing effect upon personnel and extreme lethargy and slow coordination are the natural results of cold such as is typical of the Arctic. Therefore, prefabricated houses should be designed with as few small parts, such as bolts and screws, as possible.

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Research on the use of plastics is recommended as it is much lighter than other materials, has great structural possibilities, and as compared to metal it does not intensify the cold. It would also be available in greater quantities than metal.

For specialized construction information see previous report submitted.

*Report on Pre-cut Hydrogen Shelter for Arctic Use, by Willis Knutsen, No. 71501

*Plastic Dome Shelter for S. C. R. 658, by Per Stoen, geographer, December 4, 1949, Arctic Operation Project, U. S. Weather Bureau, Washington, D. C.